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[54] FUEL CONTROL DEVICE OF AN ENGINE

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**^{5} **F02D 41/10**

[52] **U.S. Cl.** **123/492**; 123/488; 123/493

[58] **Field of Search** 123/478, 480, 488, 492, 123/493

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Primary Examiner—Willis R. Wolfe
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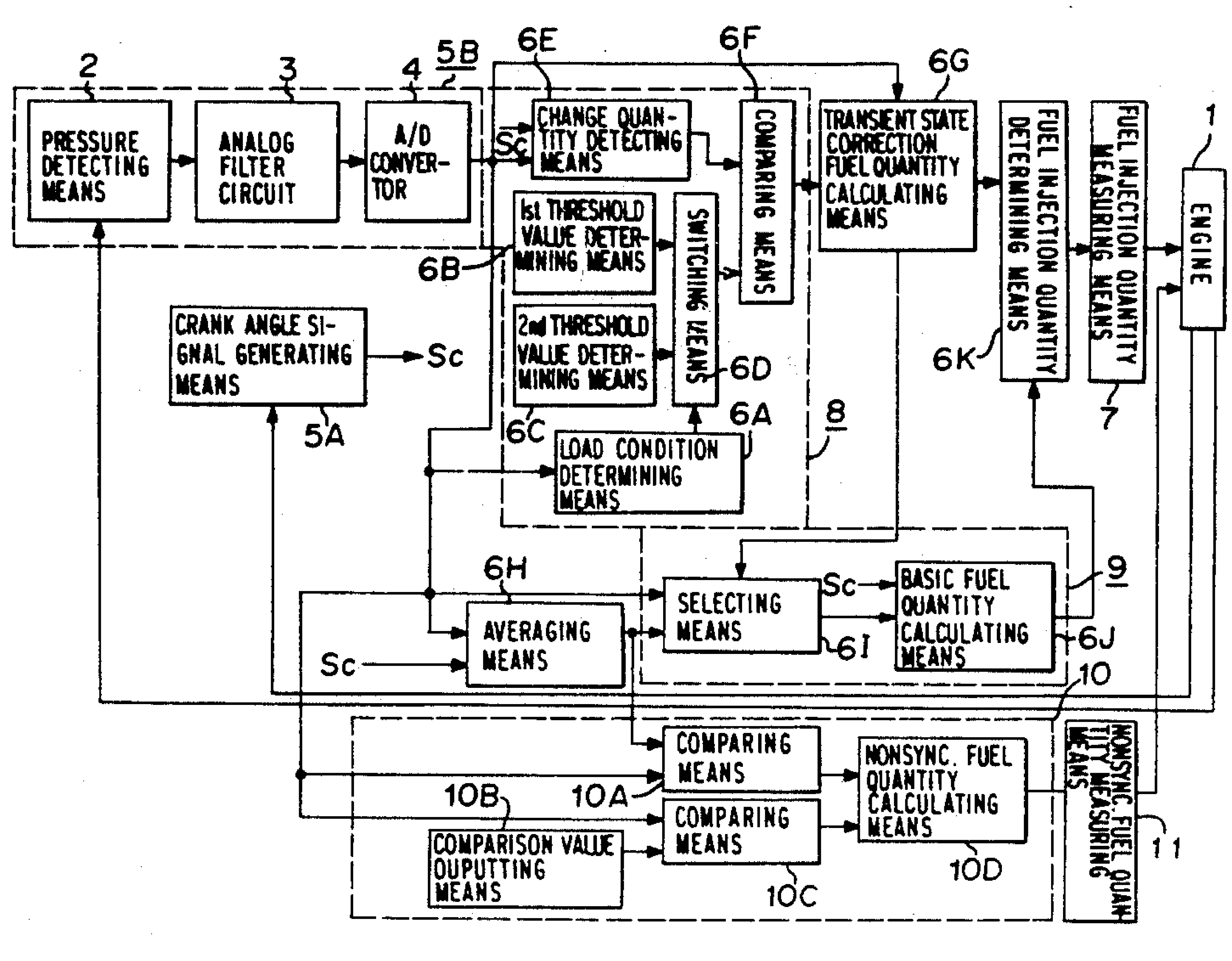
[57] **ABSTRACT**

A fuel control device of an engine which comprises: an intake pipe pressure detecting means; a crank angle signal generating means; a transient state determining means for determining a transient state of an engine; a transient state correction fuel quantity calculating means; an averaging means for averaging the pressure data in a predetermined crank angle signal period; a basic fuel quantity selecting and calculating means for calculating a basic fuel quantity after selecting an output signal of an instantaneous value of the pressure data or an output signal of the averaging means corresponding with an output level of the transient state correction fuel quantity calculating means; a fuel injection quantity determining means for calculating a fuel injection quantity by using the transient state correction fuel quantity and the basic fuel quantity; a fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the fuel injection quantity by the fuel injection quantity determining means to the engine synchronizing with a crank angle signal; a nonsynchronizing fuel quantity determining means for calculating a nonsynchronizing fuel quantity in detecting of an acceleration state of the engine by comparing an instantaneous value of the pressure data with an output signal of the averaging means; and a nonsynchronizing fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the nonsynchronizing fuel quantity by the nonsynchronizing fuel quantity determining means to the engine not synchronizing with the crank angle signal.

1 Claim, 8 Drawing Sheets



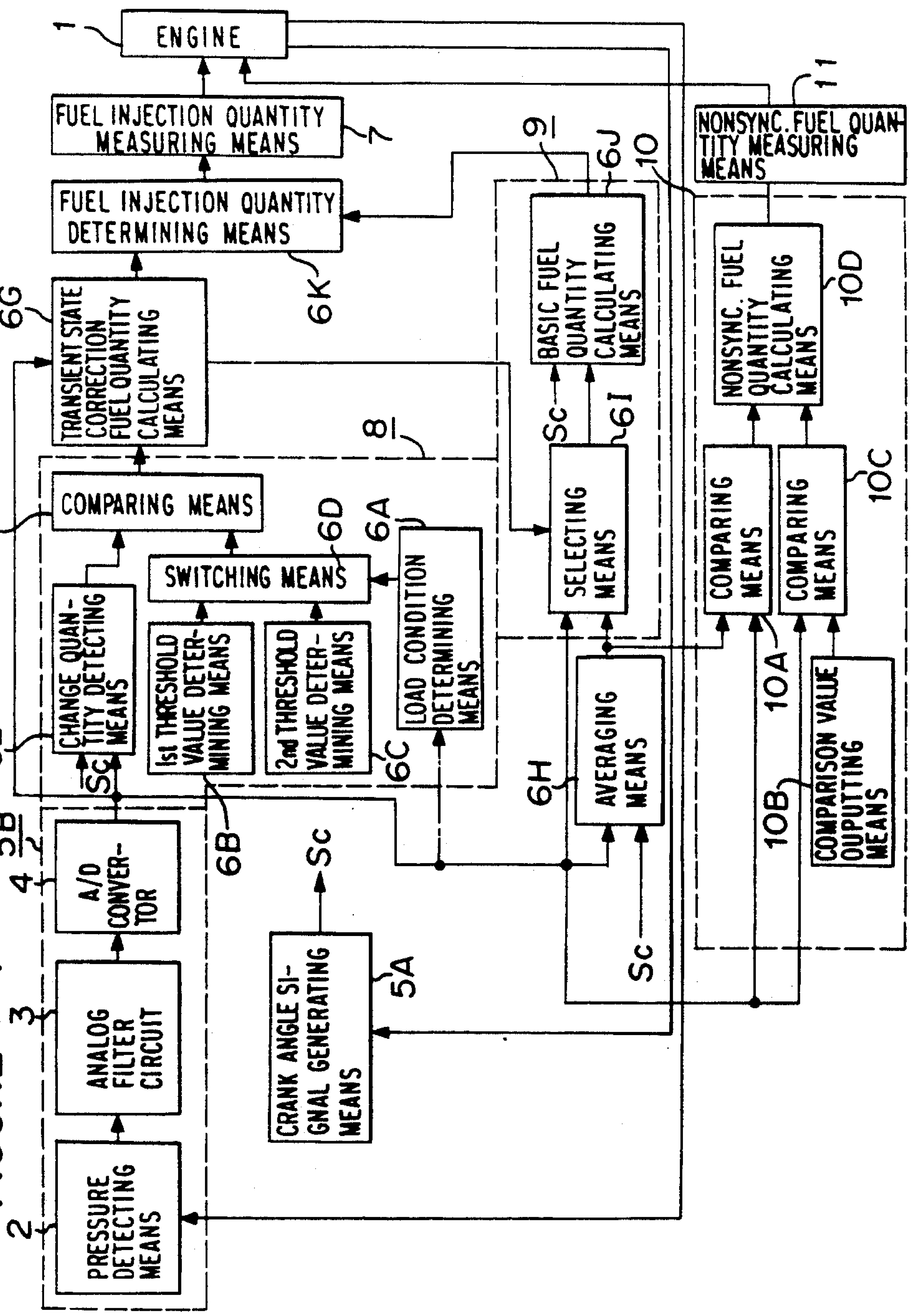

ENGINE
FUEL INJECTION QUANTITY MEASURING MEANS
FUEL INJECTION QUANTITY DETERMINING MEANS
TRANSIENT STATE CORRECTION FUEL QUANTITY CALCULATING MEANS
COMPARING MEANS
SWITCHING MEANS
CHANGE QUANTITY DETECTING MEANS
1st THRESHOLD VALUE DETERMINING MEANS
2nd THRESHOLD VALUE DETERMINING MEANS
LOAD CONDITION DETERMINING MEANS
A/D CONVERTOR
ANALOG FILTER CIRCUIT
PRESSURE DETECTING MEANS
CRANK ANGLE SIGNAL GENERATING MEANS
BASIC FUEL QUANTITY CALCULATING MEANS
SELECTING MEANS
AVERAGING MEANS
NONSYNC. FUEL QUANTITY MEASURING MEANS
NONSYNC. FUEL QUANTITY CALCULATING MEANS
COMPARING MEANS
COMPARING MEANS
COMPARISON VALUE OUPUTTING MEANS
Sc
1
2
3
4
5A
5B
6A
6B
6C
6D
6E
6F
6G
6H
6I
6J
6K
7
8
9
10
10A
10B
10C
10D
11

FIGURE 1

FIGURE 2

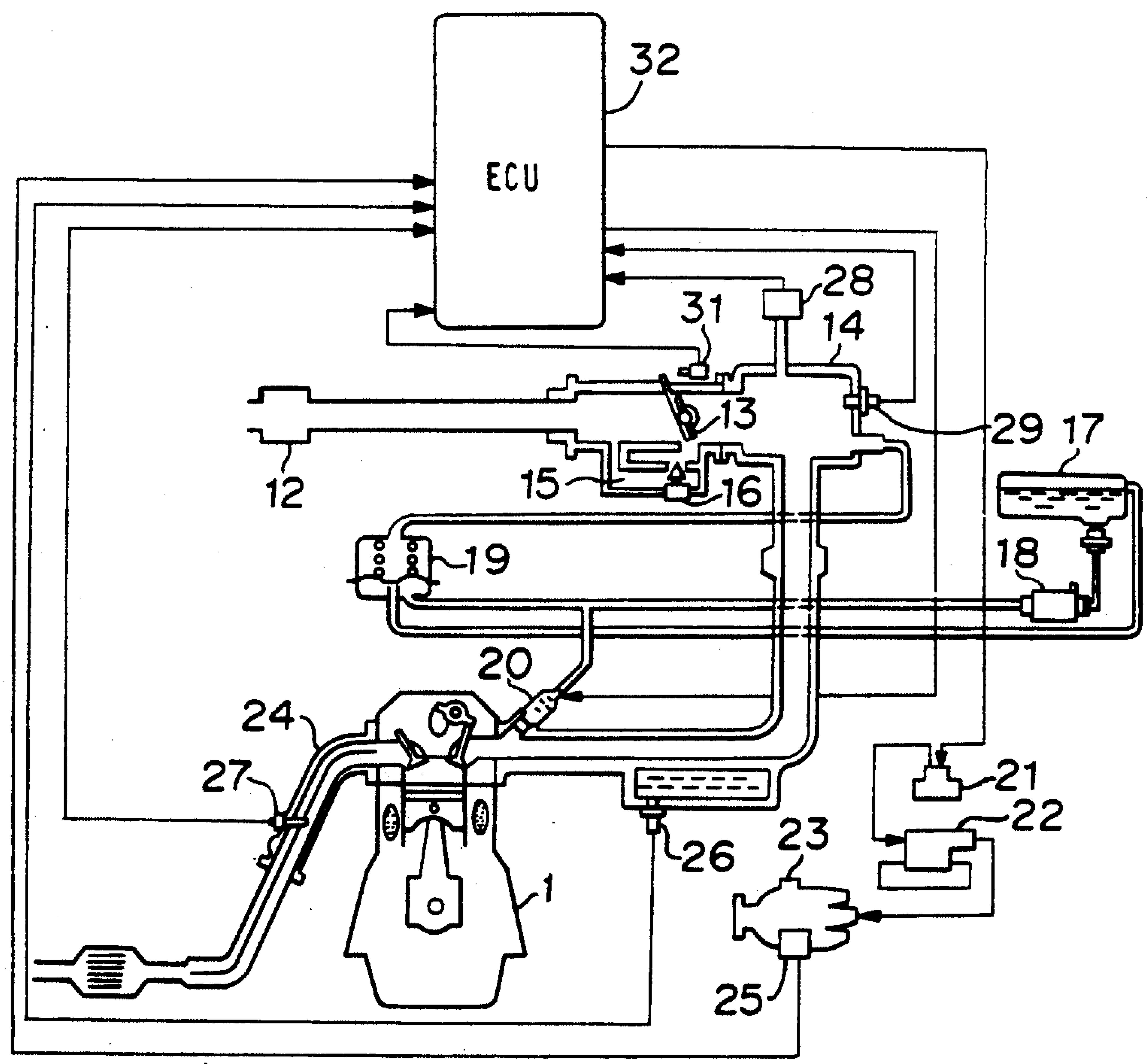
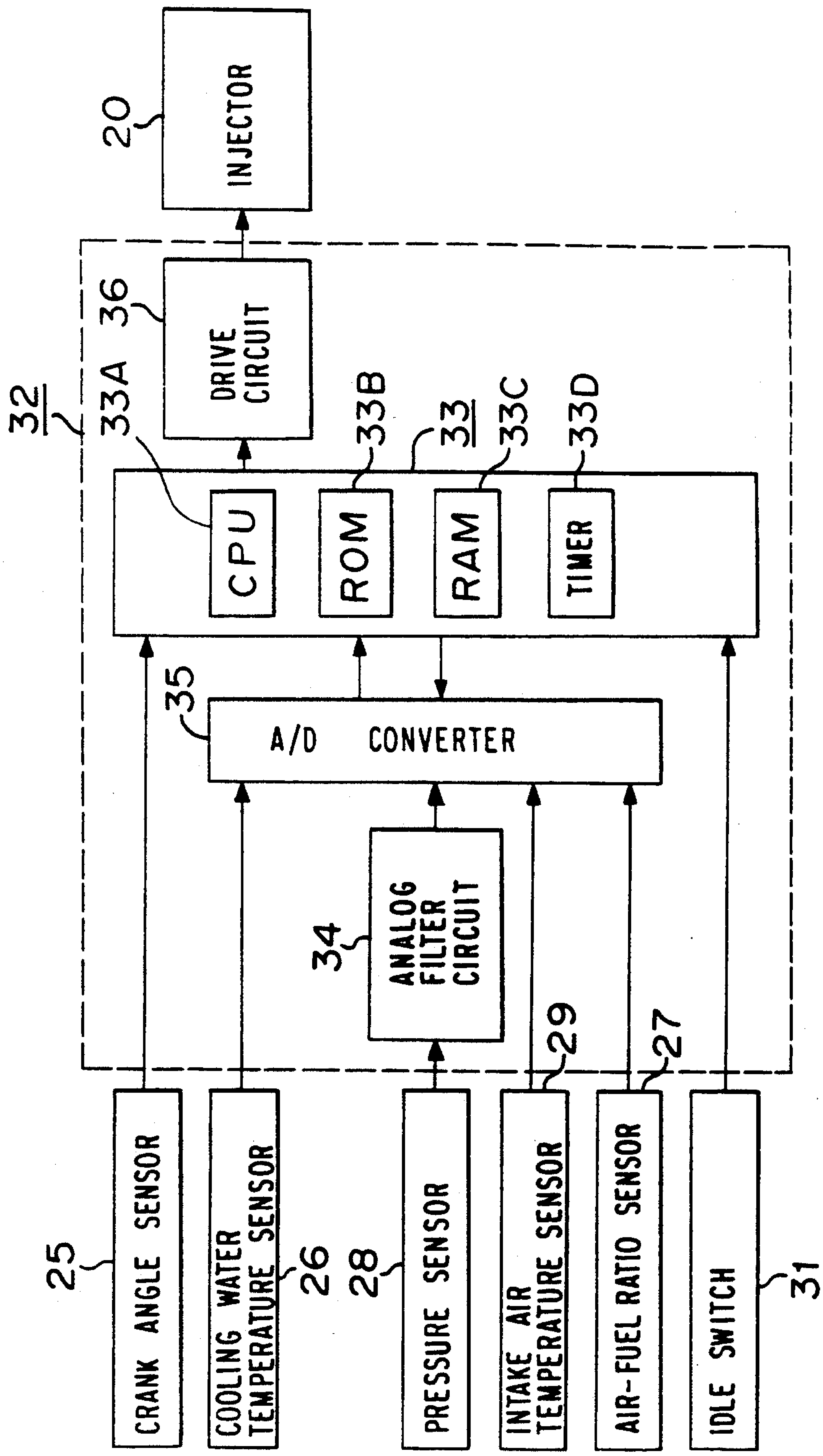


FIGURE 3


20
INJECTOR
32
36
DRIVE CIRCUIT
33A
33B
33
33C
33D
CPU
ROM
RAM
TIMER
35
A/D CONVERTER
34
ANALOG FILTER CIRCUIT
29
27
25
CRANK ANGLE SENSOR
COOLING WATER TEMPERATURE SENSOR
26
28
PRESSURE SENSOR
INTAKE AIR TEMPERATURE SENSOR
AIR-FUEL RATIO SENSOR
IDLE SWITCH
31

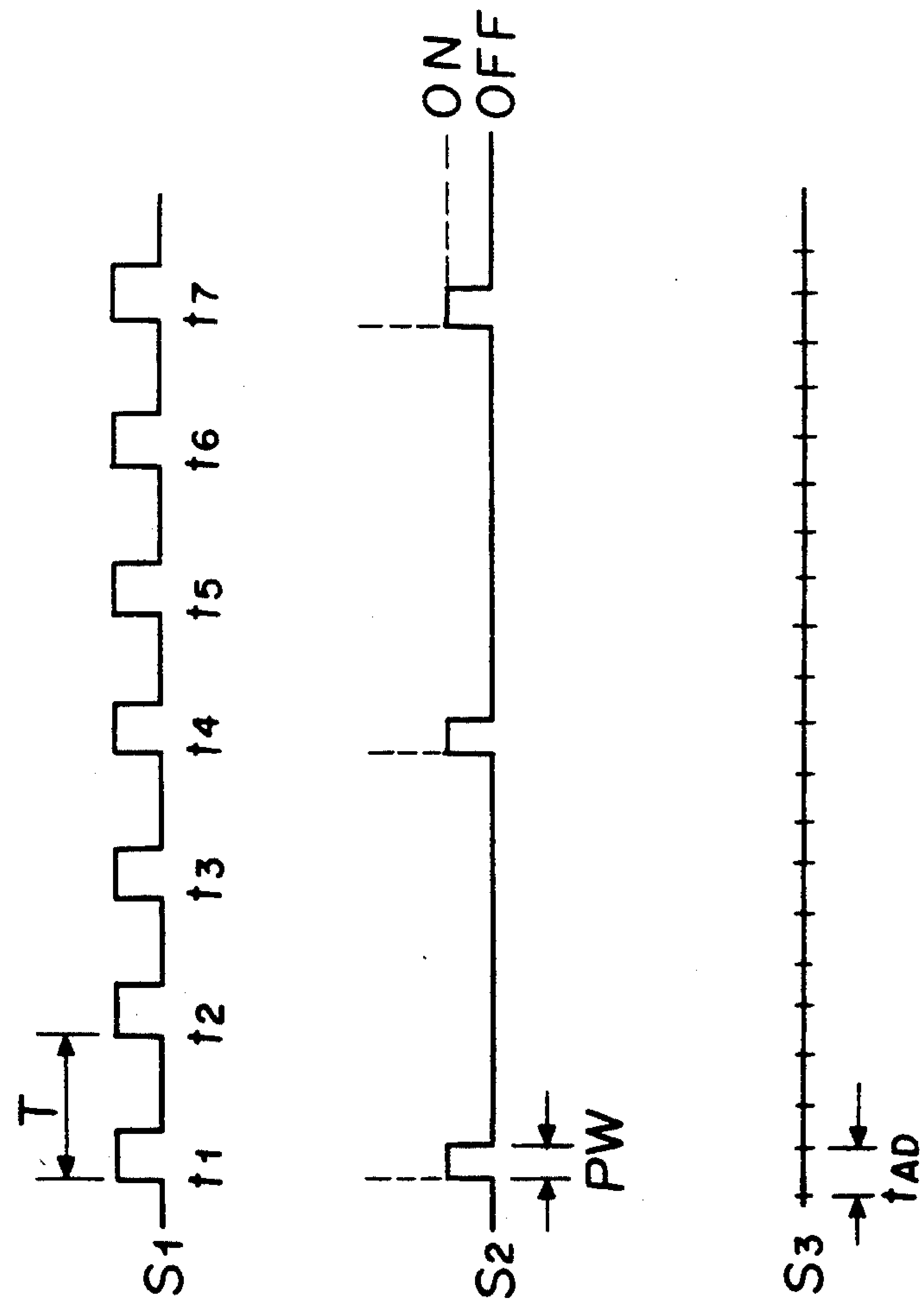


FIGURE 4A

FIGURE 4B

FIGURE 4C

FIGURE 5

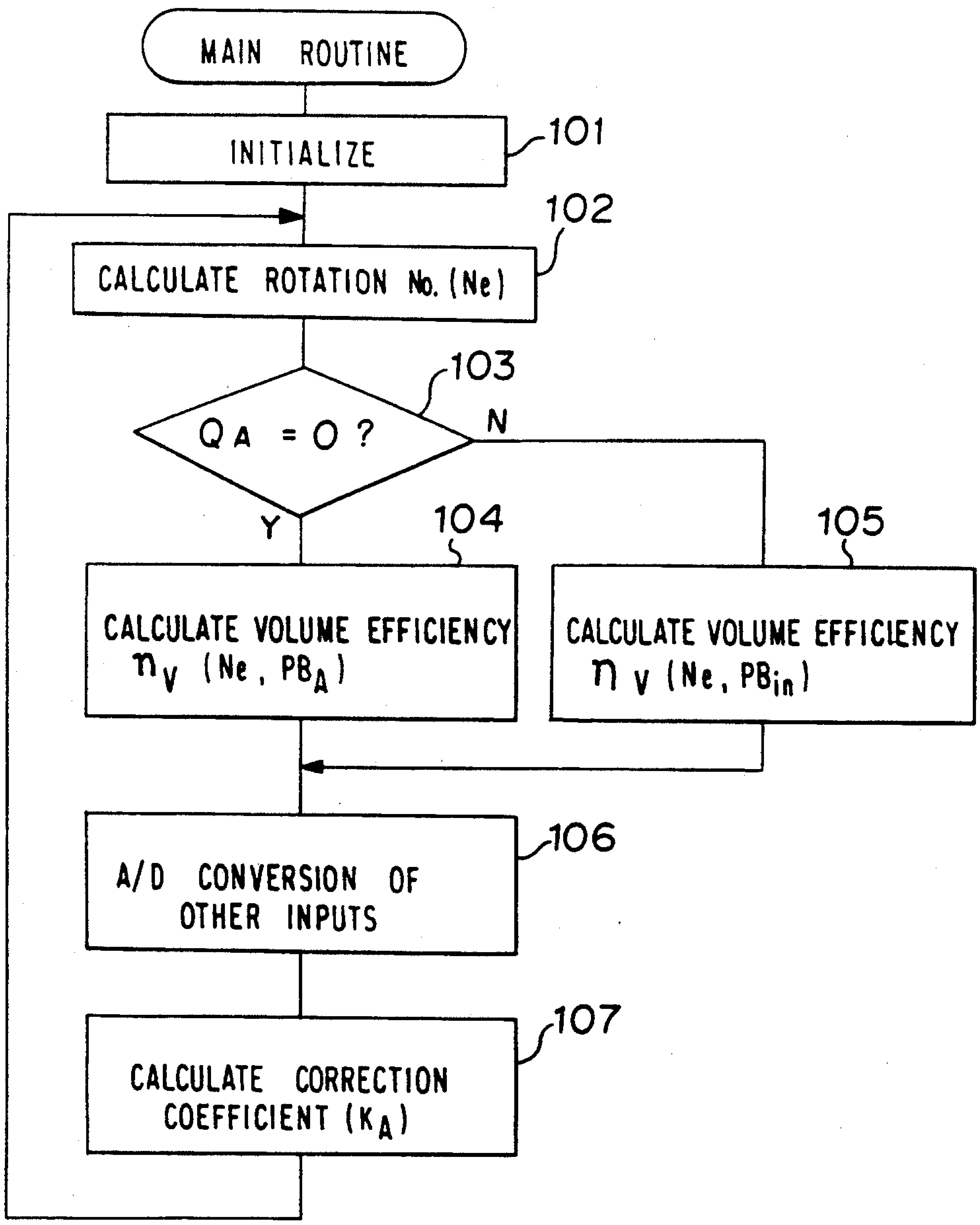

MAIN ROUTINE
INITIALIZE
101
102
CALCULATE ROTATION No. (Ne)
103
QA = O ?
N
Y
104
105
CALCULATE VOLUME EFFICIENCY ηV (Ne, PBA)
CALCULATE VOLUME EFFICIENCY ηV (Ne, PBin)
106
A/D CONVERSION OF OTHER INPUTS
107
CALCULATE CORRECTION COEFFICIENT (KA)

FIGURE 6

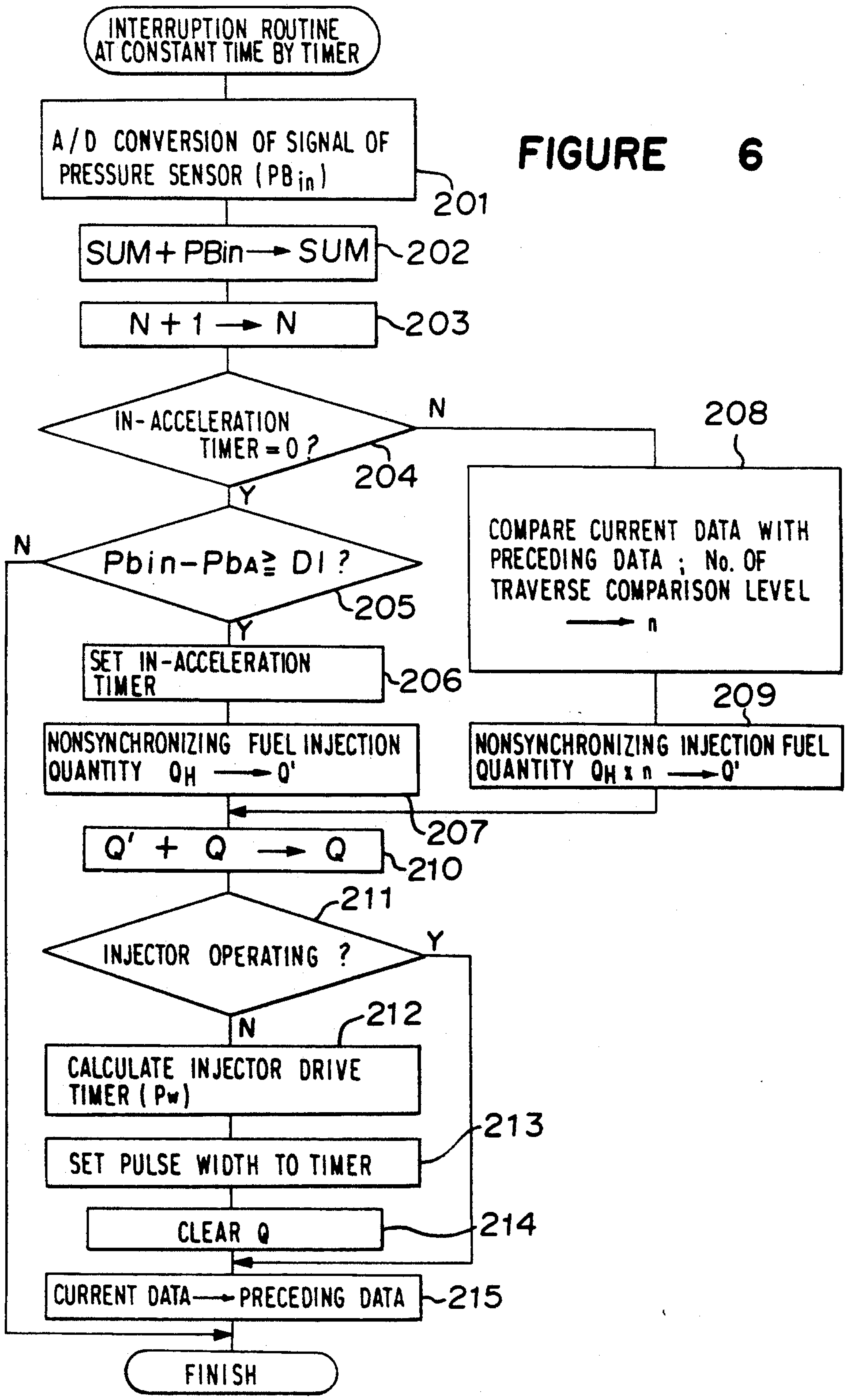

INTERRUPTION ROUTINE AT CONSTANT TIME BY TIMER
A/D CONVERSION OF SIGNAL OF PRESSURE SENSOR (PBin)
201
SUM+PBin → SUM
202
N+1 → N
203
IN-ACCELERATION TIMER = 0 ?
204
N
Y
208
COMPARE CURRENT DATA WITH PRECEDING DATA ; No. OF TRAVERSE COMPARISON LEVEL → n
Pbin−PbA ≧ DI ?
205
N
Y
SET IN-ACCELERATION TIMER
206
209
NONSYNCHRONIZING FUEL INJECTION QUANTITY QH → Q'
NONSYNCHRONIZING INJECTION FUEL QUANTITY QH x n → Q'
207
Q' + Q → Q
210
211
INJECTOR OPERATING ?
Y
N
212
CALCULATE INJECTOR DRIVE TIMER (Pw)
213
SET PULSE WIDTH TO TIMER
CLEAR Q
214
CURRENT DATA → PRECEDING DATA
215
FINISH

FIGURE 7

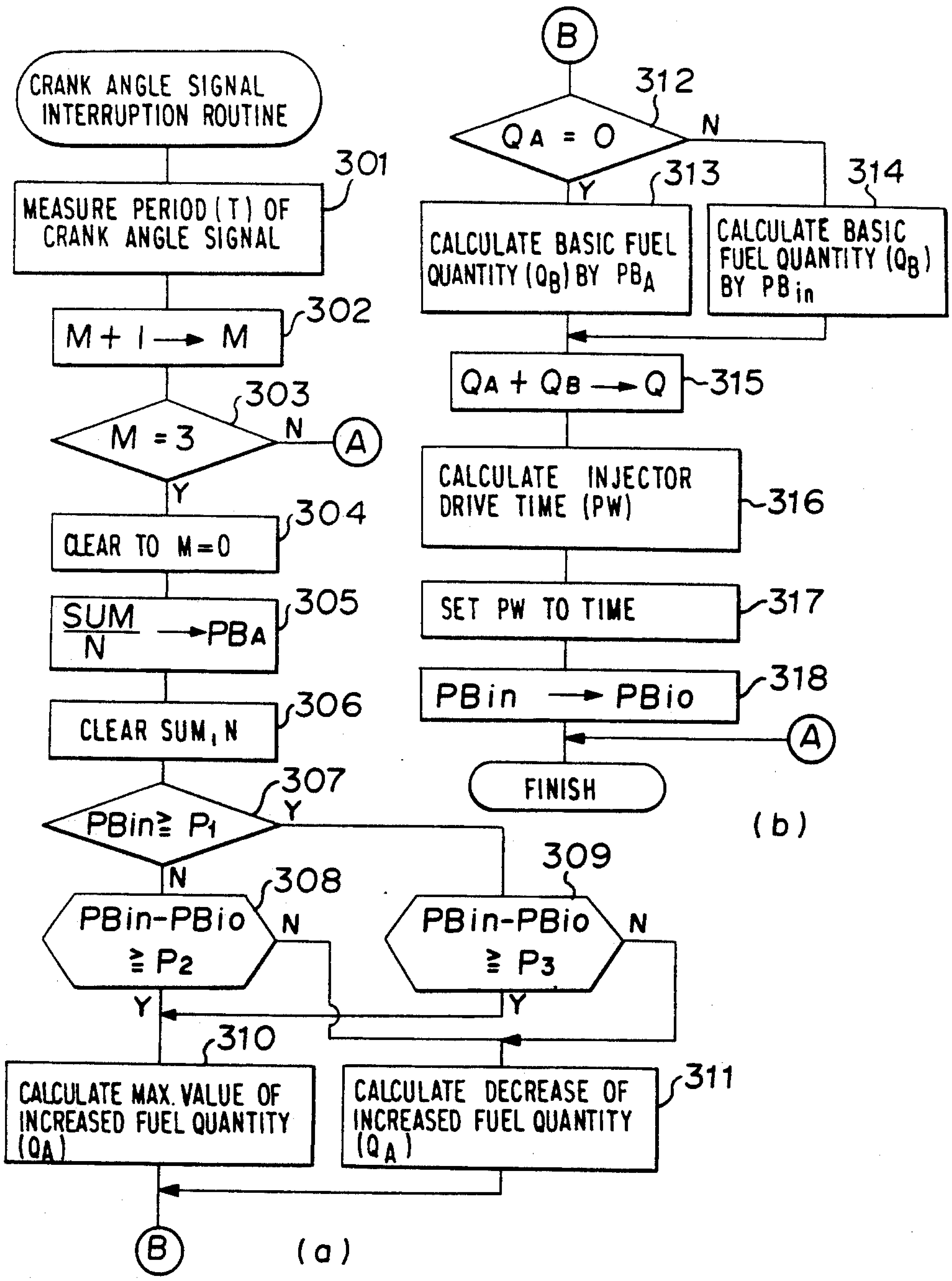
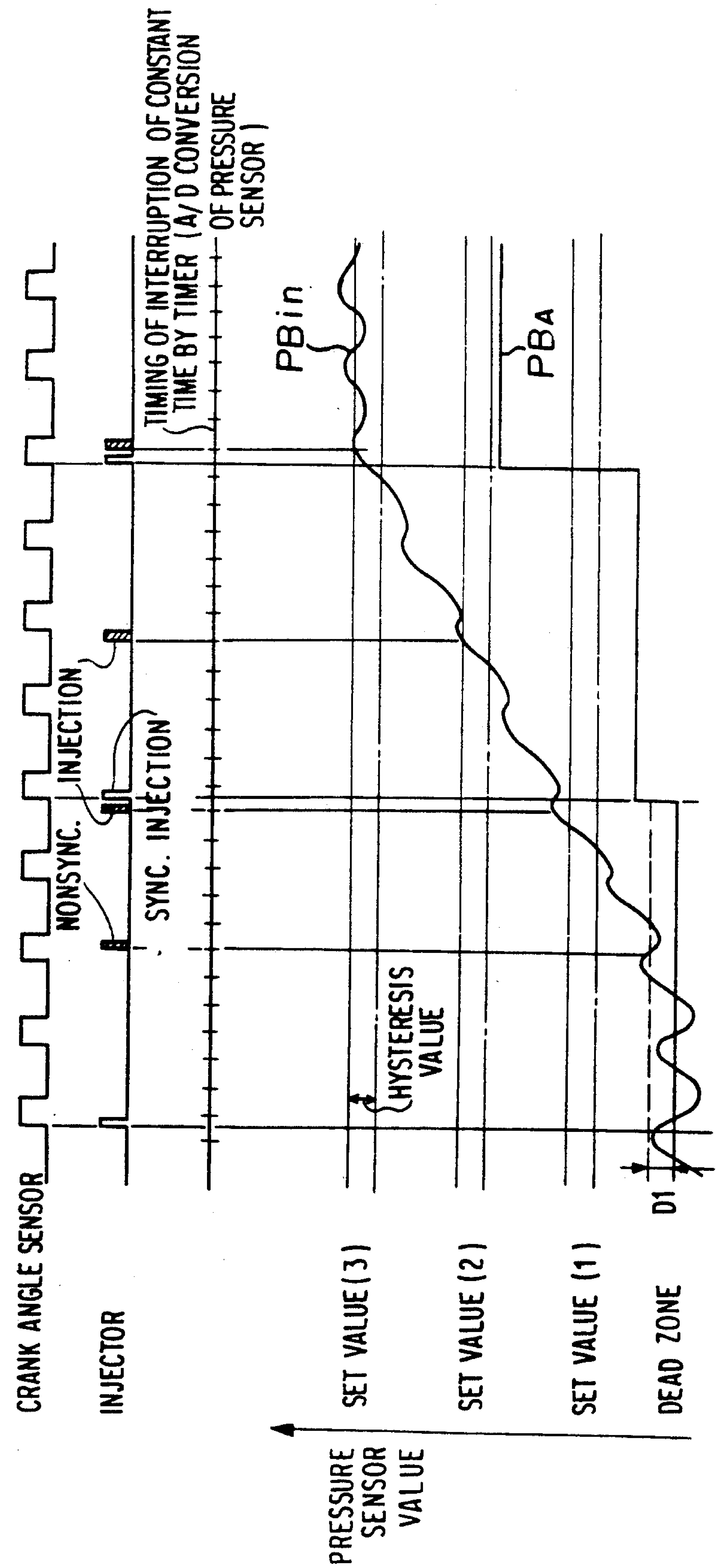

CRANK ANGLE SIGNAL INTERRUPTION ROUTINE
MEASURE PERIOD (T) OF CRANK ANGLE SIGNAL
301
M + 1 → M
302
M = 3
303
N
Y
A
CLEAR TO M=0
304
SUM/N → PBA
305
CLEAR SUM, N
306
PBin ≧ P1
307
Y
N
PBin-PBio ≧ P2
308
N
Y
PBin-PBio ≧ P3
309
N
Y
CALCULATE MAX. VALUE OF INCREASED FUEL QUANTITY (QA)
310
CALCULATE DECREASE OF INCREASED FUEL QUANTITY (QA)
311
B
(a)
B
QA = 0
312
N
Y
CALCULATE BASIC FUEL QUANTITY (QB) BY PBA
313
CALCULATE BASIC FUEL QUANTITY (QB) BY PBin
314
QA + QB → Q
315
CALCULATE INJECTOR DRIVE TIME (PW)
316
SET PW TO TIME
317
PBin → PBio
318
A
FINISH
(b)

FIGURE 8


TIMING OF INTERRUPTION OF CONSTANT TIME BY TIMER (A/D CONVERSION OF PRESSURE SENSOR)
PBin
PBA
NONSYNC. INJECTION
SYNC. INJECTION
HYSTERESIS VALUE
CRANK ANGLE SENSOR
INJECTOR
SET VALUE (3)
SET VALUE (2)
SET VALUE (1)
DEAD ZONE
D1
PRESSURE SENSOR VALUE

FUEL CONTROL DEVICE OF AN ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a fuel control device of an engine which controls quantity of fuel that is supplied to an engine of an automobile or the like.

2. Discussion of the Background

In the conventional device of this kind, pressure in an intake pipe of an engine is detected by an intake pipe pressure detecting means which is converted to a pressure data. Determination is made whether the engine is in transient state, by comparing the pressure data and a threshold value for determining a transient state. Corresponding with a result of the determination, the fuel injection quantity is calculated based on the pressure data. The fuel of this fuel injection quantity is simultaneously supplied by injection to the engine synchronizing with a predetermined crank angle. The acceleration state of the engine is swiftly detected by detecting the change quantity of an output of a throttle opening degree sensor. The fuel is simultaneously supplied to the engine not synchronizing with the crank angle.

Since the conventional fuel control device of an engine is constructed as above, a ripple variation of the pressure data is significant when the engine load is in heavy load range. Therefore the threshold value for determining a transient state is set at high value considering the ripple variation so that the transient state is not erroneously detected by the ripple variation. Henceforward, the detection sensitivity is lowered. Especially in the acceleration time of the engine in its light load range, although it is possible to control the nonsynchronizing injection by a throttle opening degree sensor at an initial state of the acceleration, the transient state detection for increasing the synchronized injection quantity is retarded. Therefore it is not possible to supply the fuel quantity in correspondence with the transient state to the engine with high response. The air-furl ratio control in the transient time is delayed, and the air-fuel ratio becomes unstable, which worsens the running performance of the engine. Furthermore, since the conventional system utilizes the throttle opening degree sensor, the cost for the control device is increased.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a fuel control device of an engine capable of stabilizing the air-fuel ratio, having a high response in the transient state, without utilizing the throttle opening degree sensor.

According to an aspect of the present invention, there is provided a fuel control device of an engine which comprises: a intake pipe pressure detecting means for detecting an intake pipe pressure and converting the intake air pressure to a pressure data; a crank angle signal generating means for generating a crank angle signal which is synchronized with a predetermined crank angle; a transient state determining means for determining a transient state of an engine by comparing a timewise change quantity of the pressure data with a threshold value for determining the transient state which is selected corresponding with a load state of the engine; a transient state correction fuel quantity calculating means for calculating a transient state correction fuel quantity based on the pressure data when the transient state of an engine is determined; an averaging means for averaging the pressure data in a predetermined crank angle signal period; a basic fuel quantity selecting and calculating means for calculating a basic fuel quantity after selecting an output signal of an instantaneous value of the pressure data or an output signal of the averaging means corresponding with an output level of the transient state correction fuel quantity calculating means; a fuel injection quantity determining means for calculating a fuel injection quantity by using the transient state correction fuel quantity and the basic fuel quantity; a fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the fuel injection quantity by the fuel injection quantity determining means to the engine synchronizing with a crank angle signal; a nonsynchronizing fuel quantity determining means for calculating a nonsynchronizing fuel quantity in detecting of an acceleration state of the engine by comparing an instantaneous value of the pressure data with an output signal of the averaging means; and a nonsynchronizing fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the nonsynchronizing fuel quantity by the nonsynchronizing fuel quantity determining means to the engine not synchronizing with the crank angle signal.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a construction diagram of the invented device;

FIG. **2** is a construction diagram of an engine unit according to the present invention;

FIG. **3** is a construction diagram of ECU according to the present invention;

FIGS. **4A** through **4C** are signal timing charts of the respective parts of the invented device;

FIGS. **5** through **7** are flow charts showing the operation of CPU in ECU according to the present invention; and

FIG. **8** is a timing chart of a nonsynchronizing injection of the invented device.

In the drawings, a numeral **1** designates an engine, **5A**, a crank angle signal generation means, **5B**, an intake pipe pressure detecting means, **6G**, a transient state correction fuel quantity calculating means, **6H**, an averaging means, **6K**, a fuel injection quantity determining means, **7**, a fuel quantity measuring means, **8**, a transient state determining means, **9**, a basic fuel quantity selection calculating means, **10**, a nonsynchronizing fuel quantity determining means, **11**, nonsynchronizing fuel quantity measuring means, **20**, an injector, **25**, a crank angle sensor, **28**, a pressure sensor, and **32**, an ECU.

The same notation in the drawings designates the same or the corresponding parts.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the followings, explanation will be given to embodiments of the present invention referring the drawings. FIG. **1** shows a construction of an embodiment of the fuel control device of the engine. In FIG. **1**, a numeral **1** designates a publicly known engine which is mounted on an automobile, **2**, a pressure detecting means for detecting a pressure in an intake pipe of the engine **1**, **3**, an analogue filter circuit for decreasing a ripple of an output signal of the pressure detecting means **2**, **4**, an A/D converter for converting an output signal of the analogue filter circuit **3** to a digital value, 5A, a crank angle signal generating means for generating a crank angle signal S_c at every predetermined crank angle of the engine **1**, 5B, an intake pipe pressure detecting means which is constituted by constituent elements of numerals **2** to **4**, and which detects an intake pipe pressure of the engine **1**, and which converts it to a digital pressure data as an output. A notation **6A** designates a load condition determining means for determining a state (for instance whether larger than or equal to a predetermined value) of the load of the engine **1** (for instance, the output signal of the intake pipe pressure detecting means **5B** or the like), **6B**, a first threshold value output means for outputting a threshold value for determining the first transient state which is utilized for transient state determination in low load of the engine, **6C**, a second threshold value output means for outputting a threshold value for determining a second transient state, the value of which is larger than the threshold value for determining the first transient state, **6D**, a switching means for switching and outputting one of the outputs of the first and second threshold value output means **6B** and **6C**, corresponding with the result of the determination of the load condition determining means **6A**. A notation **6E** designates a change quantity detecting means for detecting a change quantity of an output signal of the intake pipe pressure detecting means **5B** in a period, for instance, the one based on the crank angle signal S_c, **6F**, a comparing means for detecting the state of engine as a transient state when an output signal of the change quantity detecting means **6E** is equal to or more than a threshold value for transient state determination which is outputted from the switching means **6D**, **6G**, a transient state correction fuel quantity calculating means for calculating a transient state correction fuel quantity based on an output signal of the intake pipe pressure detecting means **5B** after receiving a transient state detecting signal of the comparing means **6F**, **6H**, an averaging means for averaging an output signal of the intake pipe pressure detecting means **5B** in a period of a predetermined crank angle signal S_c, **6I**, a selecting means for selecting and outputting one of the output signals of the intake pipe pressure detecting means **5B** and the averaging means **6H**, corresponding with an output level of the transient state correction fuel quantity calculating means **6G**, **6J**, a basic fuel quantity calculating means for calculating a basic fuel quantity by inputting the output signal of the selection means **6I** and the crank angle signal S_c, **6K**, a fuel injection quantity determining means for determining a fuel injection quantity in a drive pulse width of the injector, utilizing output signals of the transient state correction fuel quantity calculating means **6G** and the basic fuel quantity calculating means **6J**, and **7**, a fuel quantity measuring means, which measures and supplies by injection the fuel corresponding with a fuel injection quantity calculated by fuel injection quantity determining means **6K**, to the engine, synchronizing with a predetermined crank angle. A numeral **8** designates a transient state determining means composed of the constituent elements of **6A** through **6F**, which determines the transient state of the engine by comparing the threshold value for determining the transient state that is selected according to the load condition of the engine, and the change quantity of the output signal of the intake pressure detecting means **5B** in the period, for instance, the one based on the crank angle signal S_c. A numeral **9** designates a basic fuel quantity calculating means which is composed of the constituent elements of the parts **6I** and **6J**, which calculates the basic fuel quantity from a signal selected from output signals of intake pipe pressure detecting means **5B** and the averaging means **6H** corresponding with an output level of the transient state correction fuel quantity calculating means **6J**, and the crank angle signal S_c. A notation **10A** designates a comparing means which compares the output signals of the intake pipe pressure detecting means **5B** with the averaging means **6H**, and detects an acceleration state of the engine **1**, **10B**, a comparison value outputting means which determines a comparison value for determining whether the acceleration state continues, after the comparing means **10A** detects the acceleration state, **10C**, a comparing means which detects the continued acceleration state by comparing the output signals of the comparison value outputting means **10B** with the intake pipe pressure detecting means **5B**, and **10D**, a nonsynchronizing fuel quantity calculating means for calculating a nonsynchronizing fuel injection quantity when the comparison means **10A** and **10C** detect the acceleration state. The nonsynchronizing fuel quantity detecting means **10** is composed of the constituent elements of **10A** through **10D**. A numeral **11** designates a nonsynchronizing fuel quantity measuring means which measures and supplies by injection the fuel corresponding with the fuel injection quantity which is calculated by the nonsynchronizing fuel quantity determining means **10**, to the engine **1** not synchronizing with the crank angle.

FIG. 2 shows a construction of the embodiment of the engine unit. A numeral **1** designates, for instance, a publicly known four-cycle three-cylinder engine which is mounted on the vehicle such as an automobile. The air for combustion is sucked to the engine successively through the air cleaner **12**, the throttle valve **13**, and the surge tank **14**. In idling time of the engine, the throttle valve **13** is closed. The opening degree of the bypass passage **15** which bypasses the throttle valve **13**, is controlled by the thremo-wax type first idle valve **16**. The air for combustion having a quantity corresponding with the opening degree is supplied to the engine **1**. Furthermore, the fuel which is fed from the fuel tank **17** by the fuel pump **18**, the pressure of which is controlled to a predetermined injection pressure by the fuel pressure regulator **19**, is supplied to the engine by simultaneous injection through the injectors **20** which are provided corresponding with the respective cylinders of the engine **1**. Furthermore the ignition signal at ignition time is successively supplied to ignition plugs (not shown) which are provided at the respective cylinders of the engine **1**, successively through the ignition drive circuit **21**, the ignition coil **22** and the distributor **23**. The exhaust gas after combustion is exhausted to the air through the exhaust manifold **24** or the like. A numeral **25** designates a crank angle sensor which detects a rotation speed of a crank shaft of the engine **1**, which generates a crank angle signal composed of a frequency pulse signal in correspondence with the rotation speed, that, for instance, rises at BTDC 70°, and falls at TDC. A numeral **26** designates a cooling water temperature sensor which detects a cooling water temperature, and **28**, a pressure sensor, installed at the surge tank **14**, which detects the pressure in the intake pipe in absolute pressure, and outputs a pressure detection signal the size of which corresponds with the intake pipe pressure. A numeral **29** designates an intake air temperature sensor which is installed at the surge tank **14**, and which detects a temperature of the intake air, **27**, an air-fuel ratio sensor which is installed at the exhaust manifold **24**, and detects oxygen concentration of the exhaust gas, and **31**, an idle switch which detects that the throttle valve **13** is closed in idling time of the engine. The respective detected signals of the respective sensors **25** through **29** and the idle switch **31** are fed to an electronic control unit (hereinafter, ECU). The ECU **32** determines the fuel injection quantity corresponding with the transient state of the engine based on these detected signals, controls the fuel injection quantity by controlling a valve opening time for the injector **20**, and controls the drive of the ignition drive circuit **21**.

FIG. **3** shows a detailed construction of the ECU **32**. ECU **32** is composed of the microcomputer **33** which performs the various calculations or determinations, the analogue filter circuit **34** which decreases the ripple of the pressure detection signal of the pressure sensor **28**, the A/D convertor **35** which successively converts the analogue detection signal of the intake air temperature sensor **29**, the cooling water temperature sensor **26**, the air-fuel ratio sensor **27** and the output signal of the analogue filter circuit **34**, and the drive circuit **36** which drives the injector **20**, or the like. As for the output unit of the ECU, only the fuel control unit is shown in the diagram. Furthermore, the input port of the microcomputer **33** is connected to the output terminals of the crank angle sensor **25**, the idle switch **31**, and the A/D convertor **35**. The output port of the microcomputer **33** is connected to the A/D convertor **35** for sending out reference signals, as well as to an input terminal of the drive circuit **36**. Furthermore, the microcomputer **33** is composed of the CPU **33A** which performs various calculations or determinations, the ROM **33B** which stores the programs for the flows described in FIGS. **5** to **8**, the ROM **33C** as a work memory, and the timer **33D** which presets the valve opening time of the injector **20**.

FIGS. **4A** to **4C** are timing charts which shows the operation of the various parts in FIG. **3**. As shown in FIG. **4A**, the crank angle signal S_1 which is an output signal of the crank angle sensor **25**, rises at time points t_1 to t_7. The period T between the successive rise points varies with the rotation speed of the engine **1**. The drive pulse signal of the injector **20** is generated once per every three generations of the crank angle signal S_1 (which corresponds with the three cylinders of the engine **1**), by which fuel injection is performed simultaneously for the three cylinders. The A/D conversion timing S_3 at which the A/D convertor **35** converts the pressure detection signal of the pressure sensor **28** that is inputted through the analogue filter circuit **34**, into the pressure data, is as shown in FIG. **4C**. A plurality of the timing periods t_{AD} are included in a duration of time between successive injections, and are always constant (for instance 2.5 msec).

Next, explanation will be given to the operation of the CPU **33A** in the ECU **32** referring FIGS. **2** to **8**. First of all, when power source is ON, the main routine shown in FIG. **5** is initiated. In step **101**, the operation is initialized by clearing the content of the RAM **33C** and the like. In step **102**, the operation reads out the measured value of the period T of the crank angle signal S_1, and performs the calculation of the rotation number Ne, the result of which is stored in the RAM **33C**. In step **103**, the operation determines whether the increased fuel quantity Q_A, mentioned later, which is read from the RAM **33C**, is 0. If Q_A is 0, in step **104**, the operation reads out the revolution number Ne and the average value of the pressure data PB_A, mentioned later, from the RAM **33C**, and based on these values, calculates by mapping from the ROM **33B**, the volume efficiency η_v (Ne, PB_A) which is experimentally obtained beforehand, so that the air-fuel ratio becomes a predetermined value (for instance a theoretical air-fuel ratio), the result of which is stored in the RAM **33C**. When $Q_A \neq 0$, in step **105**, the operation reads out the revolution number Ne and the pressure data PB in the RAM **33C**, and based on these values, the operation calculates the volume efficiency η_v (Ne, PB_{in}), the result of which is stored in the RAM **33C**. In step **106**, the operation successively A/D converts the respective detected signals of the cooling water sensor **20**, the intake air temperature sensor **29** and the air-fuel ratio sensor **27**, the result of which is stored in the RAM **33C**. In step **107**, the operation successively reads out the cooling water temperature data, the intake air temperature data and the air fuel ratio data from the RAM **33C**, and calculates the correction coefficient K_A for correcting the basic fuel quantity, the result of Which is stored in the RAM **33C**. In this correction coefficient K_A, all of the correction coefficients such as the warming-up correction coefficient which corresponds with the cooling water temperature, the intake air temperature correction coefficient which corresponds with the intake air temperature, the air-fuel ratio feed back signal and the like, are combined. After the treatment of step **107**, the operation returns to step **102**, and the above successive operation is iterated.

On the other hand, an interruption signal is generated at every elapse of the A/D conversion timing period t_{AD}, and the operation treats the interruption routine shown in FIG. **6**. In step **201**, the operation A/D converts the output signal of the pressure sensor **28** which passed through the analogue filter circuit **34**, to the digital pressure data PB_{in} by using the A/D convertor **35**. In step **202**, the operation adds a new pressure data PB_{in} to the summation value (SUM) of the pressure data, and a new summation value of the pressure data and the pressure data PB_{in} are stored and renewed in the RAM **33C**. In step **203**, the operation adds 1 to the addition number N by which addition number N is renewed and stored in the RAM **33C**. In step **204**, the operation determines whether an in-acceleration timer, not shown, which is set in step **206**, mentioned later and which is subtracted at every predetermined time, is 0. If N is 0, that is, after a predetermined time elapses after the detection of the acceleration, the operation goes to step **205**. In step **205**, the operation determines whether the difference between the A/D transformed pressure data PB_{in} and the average value of the pressure data PB_A, mentioned later, is more than or equal to the dead zone data D_1. When the difference falls in the dead zone, the operation is finished. When the difference is equal to or more than the dead zone, the operation determines that the engine is in acceleration, and goes to step **206**. In step **206**, the operation sets the in acceleration timer which shows that the engine is in acceleration, to a predetermined value. In step **207**, the operation calculates the nonsynchronizing fuel injection quantity Q_H which is to be injected this time, as Q', which is stored in the RAM **33C**. In step **210**, the operation adds the currently calculated nonsynchronizing fuel injection quantity Q' to the nonsynchronizing fuel injection quantity Q which is not injected when the operation proceeds from step **211** to step **215** in the preceding cycle, and the nonsynchronizing fuel injection quantity Q is renewed. In step **211**, the operation determines whether the injector **20** is operating at the simultaneously injection or the like. When the injector is operating, the operation goes to step **215**. When the injector is not operating, the operation goes to step **212**, reads out the fuel quantity versus drive time conversion coefficient K_{INJ} of the injector **20**, and the dead time T_D, and performs a Calculation of $PW=Q\times K_{INJ}+T_D$, by which the injector drive time PW is calculated. In step **213**, the operation sets this injector drive time PW to the timer **33D**, by which the timer **33D** is operated for the injector drive time PW. During the operation of the timer **33D**, the injector drive pulse signal S_2 is applied to the injector **20** through the drive circuit **36**. During that period fuel is supplied by injection from the injector **20** to the engine **1**. In step **214**, the operation clears the nonsynchronizing fuel injection quantity Q. In step **215**, the operation makes the pressure data which is A/D-converted in step **201**, a preceding pressure data, and the interruption routine of FIG. **6** is finished. On the other hand, when the in-acceleration timer is not 0 in step **204**, that is, when the time falls in the predetermined time after the detection of the acceleration of the engine, the operation goes to step **208**. In step **208**, the operation always determines whether the pressure data traverses the set values (1) to (3), and detects the number of time n of traversing the set values at every determination. In step **209**, the operation calculates the nonsynchronizing fuel injection quantity which corresponds with the number of time n detected at step **208**, by the equation of $Q_H\times n=Q'$, and goes to step **210**.

Furthermore, the crank angle interruption signal is generated at every rise of the crank angle signal S_1 of the crank angle sensor **25**, and the operation treats the crank angle signal interruption routine shown in FIG. **7**. In step **301**, the measured value of the period T of the crank angle signal S_1 is stored in the RAM **33C**. Measurement of the period T is performed by for instance, a software timer or a hardware timer in the computer **33**. In step **302**, the operation adds 1 to the number of generation M of the crank angle signal S_1 by which the number of generation M is renewed. In step **303**, the operation determines whether the number of the generation of the crank angle signal M is 3. When the number of generation is below 3, the number of generation M is stored in the RAM **33C**, and a series of treatments are finished. When the number of generation $M=3$, in step **304**, the operation clears the number of generation M as 0. In step **305**, the summation value of the pressure data SUM is divided by the number of addition N, and obtains the average value of the pressure data PB_A in a single period of the fuel injection, which is stored in the RAM **33C**. This average value of the pressure data PB_A signifies an average value of the intake pipe pressure during the single period of the fuel injection. In step **306**, the summation value of the pressure data **3** and the number of addition are cleared as 0. In step **307**, the operation determines whether the pressure data PB_{in} which is obtained just before the current fuel injection, that is, just before the rise of the current pulse when the crank angle signal S_1 synchronizes with the fuel injection, is equal to or more than the first predetermined value P_1 which corresponds with the first predetermined pressure. When PB_{in} is below P_1, the operation goes to step **308**. When PB_{in} is equal to or more than P_1, the operation goes to step **309**. In step **308**, the operation determines whether the deviation ΔPB_i between the pressure data PB_{in} and the pressure data PB_{io} which is obtained just before the preceding fuel injection, that is, just before the rise of the preceding pulse when the crank angle signal S_1 is synchronized with the fuel injection, is equal to or more than the second predetermined value P_2 which corresponds with the second predetermined pressure. When ΔPB_i is equal to or more than P_2, the operation goes to step **310**. When ΔPB_i is below P_2, the operation goes to step **311**. On the other hand, in step **309**, the operation determines whether the deviation $\Delta PB_i=\Delta PB_{in}-PB_{io}$ which is obtained by the same way with that in step **308**, is equal to or more than the third predetermined value P_3 ($P_3>P_2$) which corresponds with the third predetermined pressure. When ΔPB_i is equal to or more than P_3, the operation goes to step **310**. When ΔPB_i is below P_3, the operation goes to step **311**. In step **310**, the operation calculatesd a new increased fuel quantity Q_A by multiplying the deviation ΔPB_i by a constant, and compares the result of the calculation with increased fuel quantity Q_A which is already stored in the RAM **33C**, and stores a larger value in the RAM **33C**. On the other hand, in step **311**, The operation subtracts a predetermined value α from the increased fuel quantity Q_A which is read out from the RAM **3C**. When the calculated value becomes minus, the value is clipped to 0. By such method, Q_A is renewed by performing subtraction calculation of the increased fuel quantity Q_A. The operation goes to step **312** after step **310** or **311**, and determines whether the increased fuel quantity Q_A is 0, and stores Q_A to the RAM **33C**. When Q_A is 0, the operation determines that the engine is not in the transient state correction period, and goes to step **313** If Q_A is not 0, the operation determines that the engine is in the transient state correction period, and goes to step **314**. In step **313**, the operation reads out the correction coefficient K_A, the volume efficiency η_v(Ne, PB_A) and the average value of the pressure data PB_A from the RAM **33C**, and reads out the pressure versus fuel exchange coefficient from the ROM **33B**, and calculates the basic fuel quantity Q_B by performing the calculation of $Q_B=K_Q\times K_A\times\eta_v$ (Ne, PB_A)$\times PB_A$. On the other hand, in step **314**, similar to step **313**, the operation calculates the basic fuel quantity by using the pressure data PB_{in}, according to the calculation equation of $Q_B=K_Q\times K_A\times\eta_v(Ne, PB_{in})\times PB_{in}$. The operation goes to step **315** after step **313** or **314**, where the operation calculates the supply fuel quantity Q by adding the increased fuel quantity Q_A to the basic fuel quantity Q_B. In step **316**, The operation reads out the fuel quantity versus drive time exchange coefficient K_{INJ} of the injector **20** and the dead time T_D from the ROM **33B**, and calculates the injector drive time PW as the fuel injection quantity, by performing the calculation of $PW=Q\times K_{INJ}+T_D$. In step **317**, the operation sets the injector drive time PW to the timer **33D**, and operates the timer **33D** during the period of PW. During the operation of the timer **33D**, injector drive pulse signal S_2 is supplied to the injector **20** through the drive circuit **36**, and fuel is supplied by injection from the injector **20** to the engine **1**. In step **318**, The operation renews PB_{io} by replacing the pressure data PB_{in} which is obtained just before the current fuel injection, with a pressure data PB_{io} which is obtained just before the preceding fuel injection, and the interruption treatment of FIG. **7** is finished.

Furthermore, in the above respective embodiments, for instance, in the neighborhood of the maximum revolution number, a total ripple suppressing ratio is obtained by combining a ripple suppressing ratio of the averaging of the pressure data in the averaging program treatment during a single period of the fuel injection, and the ripple suppressing ratio of the analogue filter circuit **34**. The ripple suppressing ratio of the analogue filter circuit **34** is selected so that the response necessary for determining the increase or the decrease of signals, is obtained, and the ripple is suppressed to an extent in which an erroneous determination is not made. By suitably selecting the attenuation property of the analogue filter circuit **34** and the A/D conversion timing period t_{AD}, the total ripple suppressing ratio is controlled under a predetermined value, and the influence of the ripple which accompanies the supply fuel quantity Q, can sufficiently be decreased. Furthermore, as a crank angle signal, the ignition pulse signal on the primary side of the ignition coil **22**, can be utilized. In this invention, the ignition pulse signal is a regarded to generate at every predetermined crank angle.

As stated above, according to the present invention, the transient state of the engine is detected by comparing the change quantity of the pressure data of the intake pipe pressure with a threshold value for determining of transient state of the engine which is selected corresponding with the load state of the engine. Furthermore this invention is constructed to calculate the transient state correction fuel quantity based on the pressure data by the above detection. Therefore, the transient state threshold value in the range of light load, can be smaller than that in the range of high load, which hastens the detection of the acceleration from the light load range which is frequently performed in the practical driving. Furthermore, in the initial state of the acceleration of the engine, since the fuel injection is performed in nonsynchronizing way based on the change of the pressure data, the air-fuel ratio in the transient state, can be stabilized in the total driving range, which promotes the driving performance. Since the throttle opening degree sensor is not utilized, a fuel control device of an engine excellent in cost performance, can be obtained.

What is claimed is:

1. A fuel control device of an engine which comprises:

a intake pipe pressure detecting means for detecting an intake pipe pressure and converting the intake air pressure to a pressure data;

a crank angle signal generating means for generating a crank angle signal which is synchronized with a predetermined crank angle;

a transient state determining means for determining a transient state of an engine by comparing a timewise change quantity of the pressure data with a threshold value for determining the transient state which is selected corresponding with a load state of the engine;

a transient state correction fuel quantity calculating means for calculating a transient state correction fuel quantity based on the pressure data when the transient state of an engine is determined;

an averaging means for averaging the pressure data in a predetermined crank angle signal period;

a basic fuel quantity selecting and calculating means for calculating a basic fuel quantity after selecting an output signal of an instantaneous value of the pressure data or an output signal of the averaging means corresponding with an output level of the transient state correction fuel quantity calculating means;

a fuel injection quantity determining means for calculating a fuel injection quantity by using the transient state correction fuel quantity and the basic fuel quantity;

a fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the fuel injection quantity by the fuel injection quantity determining means to the engine synchronizing with a crank angle signal;

a nonsynchronizing fuel quantity determining means for calculating a nonsynchronizing fuel quantity in detecting of an acceleration state of the engine by comparing an instantaneous value of the pressure data with an output signal of the averaging means; and

a nonsynchronizing fuel quantity measuring means for measuring a fuel quantity for supplying by injection fuel of the nonsynchronizing fuel quantity by the nonsynchronizing fuel quantity determining means to the engine not synchronizing with the crank angle signal.

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